Introduction to Physical Science

Equations of Motion

Presented by Robert Wagner

Notation

- Take the initial time to be zero
  - so,
- Drop the f subscript for final values
  -
- Assume constant acceleration (avoid calculus!)
  -

Kinematic Equations

- Solving for displacement (Δx) and final position (x)
  - Equation 1:
  - Equation 2: (for constant acceleration)

Example

- A jogger runs with an average velocity of 4.00 m/s for 2.00 minutes. What is the final position?
  - Draw a sketch
  - Identify equation - final position
  - Identify known values
  - Convert units as needed (minutes to seconds)
  - Enter values in the equation

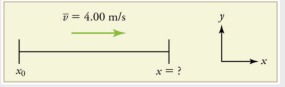

Figure 2.26

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Example

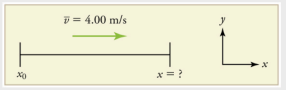

Figure 2.26

- A jogger runs with an average velocity of 4.00 m/s for 2.00 minutes. What is the final position?
  - Draw a sketch
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  - Identify known values
  - Convert units as needed (minutes to seconds)
  - Enter values in the equation

$$x = x_o + \bar{v}t$$

$$\bar{v} = 4.00\ m/s\ ;\ \Delta t = 2.00\ min\ ;\ x_o = 0\ m$$

$$2.00\ min x \frac{60\ seconds}{1\ min} = 120.\ seconds$$

$$x = 0\ m + (4.00\ m/s)(120.\ s)$$

$$x = 480.\ meters$$

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Kinematic Equations

- Solving for final velocity
  -
  - Applies with constant acceleration

Example

- An airplane lands with an initial velocity of 70.0 m/s and decelerates at 1.50 m/s^2 for 40.0 s. What is the final velocity?
  - Draw a sketch
  - List known values ; identify unknown
  - Determine equation to use
  - Plug in known values and solve
- Acceleration negative means that final velocity will be less than initial velocity

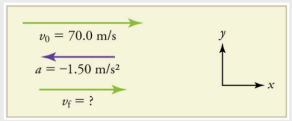

Figure 2.28

Image Credit: OpenStax College Physics - Figure 2.28 CC BY 4.0

Example

- An airplane lands with an initial velocity of 70.0 m/s and decelerates at 1.50 m/s^2 for 40.0 s. What is the final velocity?
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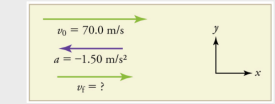

Figure 2.28

$$v_o = 70.0\ m/s\ ;\ a = -1.50\ m/s^2\ ;\ t = 40.0\ s$$

Unknown = v_f

$$v = v_o + at$$

$$v = 70.0\ m/s + (-1.50\ m/s^2)(40.0\ s)$$

$$v = 10.0\ m/s$$

Image Credit: OpenStax College Physics - Figure 2.28 CC BY 4.0

Kinematic Equations

- Solving for the final position when velocity is not constant
  - Acceleration 0
-

Example

- A dragster accelerates at 20.0m/s^2 for 5.56 seconds. How far does it travel during this time?
  - Draw a sketch
  - Identify known values and unknown
  - Identify equation to use
  - Plug in known values and solve equation

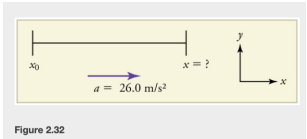

Figure 2.32

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Example

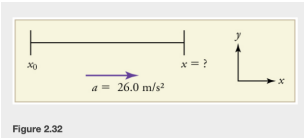

Figure 2.32

- A dragster accelerates at 20.0m/s^2 for 5.56 seconds. How far does it travel during this time?
  - Draw a sketch
  - Identify known values and unknown
  - Identify equation to use
  - Plug in known values and solve equation

$v_o = 0\ ;\ a = 26.0\ m/s^2\ ;\ t = 5.56\ s$

Unknown: x

$$x = x_o + v_o t + \frac{1}{2}at^2$$

$x_o\ and\ v_o$ are both zero

$$x = \frac{1}{2}at^2$$

$$x = \frac{1}{2}(26.0\ m/s^2)(5.56\ s)^2$$

$$x = 402\ m$$

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Kinematic Equations

- Solving for the final velocity when velocity is not constant
  - Acceleration 0
-

Example

- Calculate the final velocity of the dragster from the previous example without using the time.
  - Draw a sketch
  - Identify known values and unknown
  - Identify equation to use
  - Plug in known values and solve equation

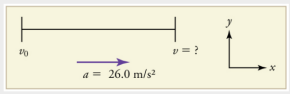

Figure 2.33

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Example

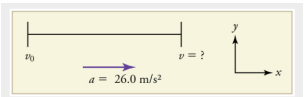

Figure 2.33

- Calculate the final velocity of the dragster from the previous example without using the time.
  - Draw a sketch
  - Identify known values and unknown
  - Identify equation to use
  - Plug in known values and solve equation

$v_o = 0\ ;\ (x - x_o) = 402\ m\ ;\ a = 26.0\ m/s^2$

Unknown - final velocity

$$v^2 = v_o^2 + 2a(x - x_o)$$

$$v^2 = 0^2 + 2(26.0\ m/s^2)(402\ m)$$

$$v^2 = 2.09x10^4\ m^2/s^2$$

$$v = \sqrt{2.09x10^4\ m^2/s^2} = 145\ m/s$$

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Kinematic Equations

- Summary of the kinematic equations (constant acceleration)
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  -
  -
  -
  -

Problem Solving Strategies

- 1) Examine the situation and draw a simple sketch
- 2) Make a list of what is known
- 3) Identify what needs to be determined in the problem
- 4) Find an equation or equations to help you solve the problem
- 5) Substitute known values into the equation - check units
- 6) Is the answer reasonable?

Summary

- The kinematic equations can be used to solve many problems in one dimension
- In these, we assume that the acceleration is constant
- Utilizing problem solving strategies will help you to solve various physics problems